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Travelling light: Fouling biota on macroplastics arriving on beaches of remote Rapa Nui (Easter Island) in the South Pacific Subtropical Gyre

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ABSTRACT

Marine anthropogenic debris was sampled from two beaches on the remote South Pacific island Rapa Nui (Easter Island). Abundance, composition, and the attached fouling assemblages on stranded litter were analysed. Most litter (n = 172 items found) was composed of plastic material, and 34% of all litter items were fouled. The main fouling species was the encrusting bryozoan *Jellyella eburnea*. Transporting vectors were exclusively made from plastics and were mainly small items and fragments, probably stemming from the South Pacific Subtropical Gyre. We present the first report of *Planes major*, *Halobates sericeus*, and *Pocillopora* sp. on anthropogenic litter in the South Pacific.

1. Introduction

Non-indigenous species (NIS) and pollution of marine and coastal environments are amongst the most important threats to biodiversity that should be urgently treated (Regulation (EU) No 1143/2014, 2014; Bergmann et al., 2015). One of the manifold impacts of marine anthropogenic litter on the environment is its role as a transport vector for attached biota, amongst them non-native invasive species (Kiessling et al., 2015; Rech et al., 2016). Although this phenomenon has received very little scientific and public attention in the past, floating rafts are now considered to play an important role in biota introduction and dispersal, even in areas where there are several other vectors known to generate a high risk of introducing NIS, like aquaculture or shipping and ports (e.g. Rech et al., 2018a, 2018b). Examples are British brackish and marine waters, where floating debris is listed as the third most common vector for NIS transport (Minchin et al., 2013); in the Mediterranean region, > 80% of NIS might have arrived or dispersed on flotsam of anthropogenic origin (Galgani et al., 2014). This vector may be especially important in remote regions, particularly remote islands, where other vectors of NIS introduction, like aquaculture, transport in ballast water, or hull fouling are absent or scarce. Species transport by natural floating material, like pumice or algal rafts, is well known, and has importantly influenced biotic communities on islands (Thiel and Gutow, 2005a; Fraser et al., 2011; Nikula et al., 2013; Kiessling et al., 2015). Since the introduction of plastic as a common material for everyday items, its production has risen to 335×10^9 kg in 2016 (PlasticsEurope, 2018). Due to the high influx of discarded plastic items to the oceans worldwide, rafting opportunities for marine species have increased dramatically (Barnes, 2002; Kiessling et al., 2015). Plastics make for particularly stable and persistent rafts. Such floating substrata and their attached communities can float over wide distances. Several trans-oceanic rafting events are known. A recent major event was the trans-Pacific rafting from Japan to North America of nearly 300 marine coastal species on anthropogenic rafts detached by the 2011 tsunami in Japan (Calder et al., 2014; Carlton et al., 2017; McCuller and Carlton, 2018; Miller et al., 2018). Another example worth to be mentioned is the trans-Atlantic rafting of non-indigenous molluscs and barnacles to British and Irish shores (Minchin et al., 2013; Holmes et al., 2015).

Plastic debris and flotsam/jetsam are not distributed homogeneously in the oceans. The floating items are moved with oceanic currents and accumulate in oceanic divergence zones. The biggest and most important of them are the five principal oceanic gyres, situated in the North- and South Pacific, North-and South Atlantic and Indian Ocean. Contrary to widespread popular opinion, these accumulations are not visible litter islands, but are defined by significantly higher concentrations of litter items and particles compared to oceanic waters outside the gyres (Eriksen et al., 2013, 2014; Ryan, 2014; Miranda-Urbina et al., 2015). Not only debris, but also attached micro and macrobiota are travelling in the gyres and have been increasingly studied in the last years (e.g. Goldstein et al., 2012, 2014; Bryant et al.,

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A significant rise of marine debris accumulation over the last 30 years has been documented from remote islands of the southern hemisphere, and it has been shown that South Pacific islands accumulate exceptionally high quantities of marine debris (Barnes, 2005; Lavers and Bond, 2017; Hidalgo-Ruz et al., 2018). The highest density of debris reported worldwide was found on unpopulated and rarely visited Henderson island in the South Pacific gyre region (Lavers and Bond, 2017). This suggests that many remote islands, which are usually thought to be rather protected from human impact, are particularly impacted by anthropogenic marine debris accumulation and its deleterious consequences. Rapa Nui is an inhabited, but remote island, located in the South Pacific Subtropical Gyre (SPSG). Marine litter rapidly accumulates within the Easter Island ecoregion, with items coming from the South American continent reaching the area within < 2 years (Martinez et al., 2009). In a citizen-science study carried out on the island‘s beaches, accumulation of microplastics was found to be almost thirty times higher than on Chilean continental beaches (Hidalgo-Ruz and Thiel, 2013) and also floating macrolitter in the waters of the SPSG reaches much higher abundances than in continental waters (Miranda-Urbina et al., 2015). Little is known about native and non-native biota of Rapa Nui; however, one non-native fouling bryozoan species, *Jellyella eburnea*, has been found on plastic debris stranded on the island‘s beaches and is thought to have been introduced via this vector (Moyano, 2005).

The aim of this work was to investigate the extent of arrival of fouling biota on floating items on beaches of this remote island. Particularly, the objectives were to (i) characterize the abundance and composition of macrolitter deposited at Rapa Nui, (ii) infer its origin (as local versus imported via the oceanic gyre), and (iii) determine its role as vector of fouling biota. The investigation is based on the hypothesis that macrolitter items and fragments from the currents of the South Pacific Subtropical Gyre (SPSG) and the marine litter accumulation zone in the center of the SPSG arrive on Rapa Nui. As such items and fragments are known to travel for prolonged periods of time with the oceanic currents, we predicted to find highly persistent plastic items of high floatability, and in an advanced state of fragmentation. We expected such items to serve as dispersal vectors of fouling biota.

2. Material and methods

2.1. Sampling site

The study presented here was carried out on two beaches of the South Pacific island Rapa Nui (English: Easter Island): Anakena beach (27°04′23.8”S 109°19′23.6”W, north-western orientation) and Ovahe beach (27°04′26.0”S 109°18′51.0”W, eastern orientation). They are the island's only accessible sandy beaches, both situated on the island's northern coast, frequently used by beach goers, and relatively protected within small bays (Fig. 1). The main sampling area was proportional to the length of the beach and was 480 m^2 on Anakena beach and 160 m^2 on Ovahe beach.

2.2. Sampling strategy

Each beach was sampled during approximately two hours, at low tide and daylight in the beginning of April 2017. All anthropogenic litter was counted along the most recognizable tideline +1 m to both sides on both beaches. Non-fouled and fouled anthropogenic litter items were counted separately, to estimate the abundance of both types of litter and to calculate the percentage of fouled items. At Ovahe beach, an opportunistic sampling of a marine litter accumulation patch (area: 6 m^2) at the rocky backshore of the beach was done additionally. As no such backshore litter patch was present at the Anakena beach, there was a total of three sampling points in this study: (1) Ovahe – tideline (OVA-TL), (2) Anakena – tideline (ANA-TL), and (3) Ovahe – backshore (OVA-BS). The minimum size of debris items counted in this study was of 5 cm in either length, width, height, or diagonal. Fouled litter items were photographed with a size reference and taken to the lab for measuring and further analysis.

2.3. Data analysis

All litter items were sorted according to the categories and codes established by United Nations Environment Programme (UNEP; Cheshire et al., 2009; Table 1). Fouled items as well as encrusting bryozoan colonies, if present, were measured and the total surface area, as well as surface area encrusted by bryozoans was calculated for each item by SR. The percentage of surface covered by encrusting bryozoans was then calculated for each item. Afterwards, the biota attached to each item were scraped off, counted, and identified to the lowest taxonomic level possible. The taxonomic diversity of the fouling assemblage as well as the percentage of bryozoan cover on litter items was compared between the three sampling points (OVA-TL, ANA-TL, OVA-BS) and UNEP item categories using permutational analysis of variance (PERMANOVA; Anderson et al., 2008), based on Bray-Curtis similarities. The analyses were carried out with PRIMER 6 software (Clarke and Gorley, 2006). Results were regarded as statistically significant at a p-value < 0.05.

2.4. Genetic analysis and visual identification

All biota attached to litter items in this study were identified to the most specific taxonomic level possible using state of the art taxonomic guides and literature (Herring, 1961; Foster and Newman, 1987; Hayward and Ryland, 1995; Møller Andersen and Cheng, 2004; Heckman, 2008; Fernández et al., 2014; Chan and Cheang, 2015; Harada et al., 2016). Taxon nomenclature follows World Register of

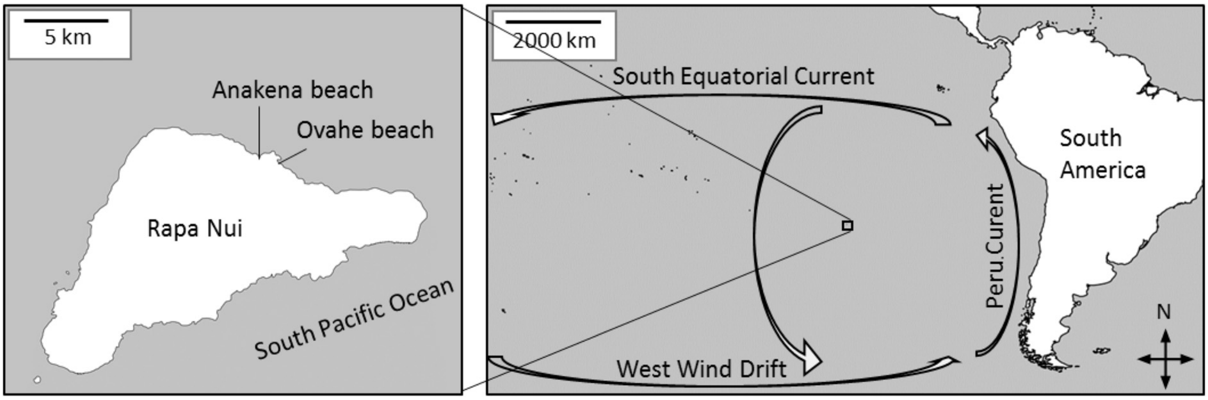

Fig. 1. Map of Rapa Nui island and the surrounding currents of the South Pacific Subtropical Gyre.